6.4
EU-Project MICADO

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Many European states intend direct geological disposal of high active spent fuel elements into repositories. After decay storage direct, disposal means that the fuel elements will be stored in special containers and moved to the repository without further treatment. When making a safety-related assessment of this form of final disposal, it has to be considered that in case of a failure of the containers, the fuel elements could theoretically get in contact with water occurring in the host rock of the repository. In such a case the radioactive material might dissolve in the water and the thus generated solution could reach the groundwater located in the upper layers of the earth in the long term. Therefore, methods and theoretical models to describe the potential dissolution processes of fuel elements have been developed at the international level for several decades. Data which were gained in experiments form the basis for these developments. The EU-sponsored project MICADO (Model uncertainty for the mechanism of dissolution of spent fuel in a nuclear waste repository) studies in international cooperation if there are sufficiently reliable models to assess the corrosion resistance of spent fuel elements. Together with partners from France (IRSN) and Belgium (Bel V), GRS has been participating in the MICADO research activities since 2006.

Project MICADO

Co-operation partners. More than 20 organisations from seven countries participate in MICADO. Within the scope of MICADO, experts from the fields of electrochemistry, geochemistry and radiochemistry evaluate the different approaches to predict long-term processes on spent fuel elements and containers in respect of their applicability in safety analyses for repositories. The comparison of the approaches is of particular interest from both the operators' and the authorities' point of view.

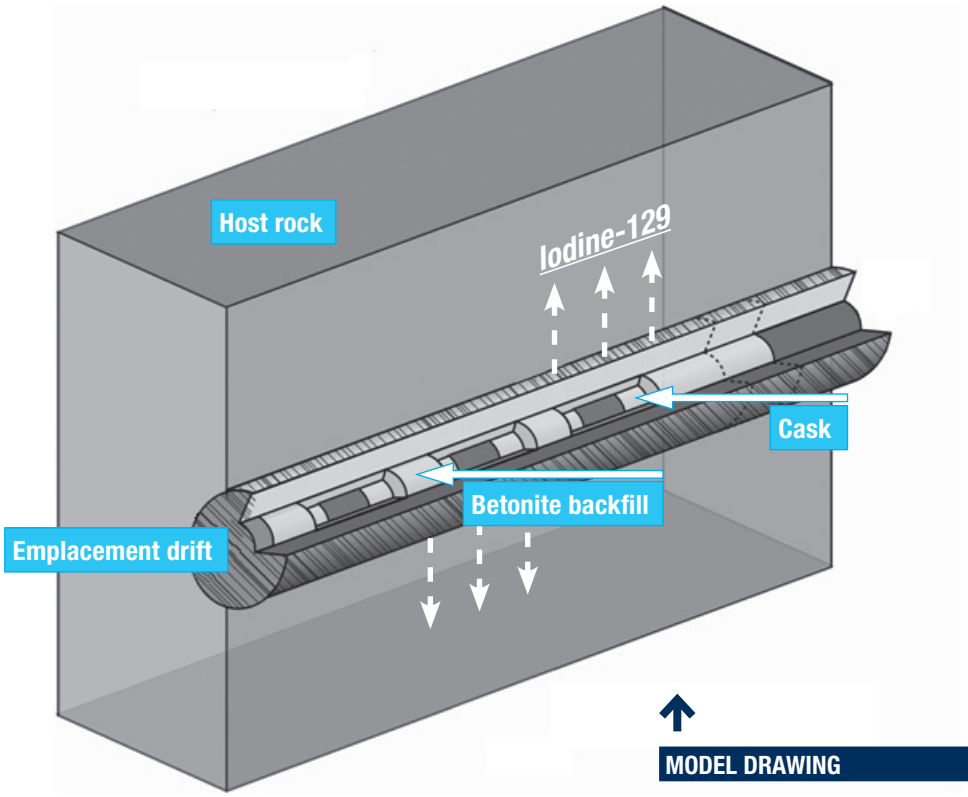
Tasks and objective. Key task is the assessment of the uncertainties in the experimental data base and in the underlying models. An extrapolation of the empirical data which were measured within few years to periods of hundreds of thousands of years is a challenge. Also the mechanistic models which transfer experimental observations to long periods show uncertainties. Therefore, MICADO is primarily aimed at assessing the quality of the experimental data and approaches by comparing the different approaches and underlying hypotheses. In this context, two forms of uncertainties are examined: Uncertainties which result from experimental data and uncertainties which result from different predictions of the models. To this end, the institutions involved carry out detailed analyses of fuels and modellings to improve the experimental data base on the one hand, and to reduce the modelling uncertainties on the other hand. In addition, the MICADO project allows the participating organisations to exchange their findings on the existing approaches and methods in the analysis of the long-term corrosion behaviour of containers and fuel elements. Finally, MICADO shall also contribute to the identification of issues relating to future research and point out which of the existing uncertainties can be further reduced.

Contributions by GRS and its partners

Studies into the release of the radionuclide iodine-129. In co-operation with its partners Bel V (Belgium) and IRSN (France), GRS examines the uncertainties of the simulated release of the radionuclide iodine-129 on basis of the French repository concept. The concept provides for the emplacement of disposal containers with spent fuel elements in drifts and sealing the latter with bentonite against ingress of groundwater (see Fig. 70 »MODEL DRAWING«).

Codes MELODIE and SUSA

The modelling of radionuclide release and transport according to the French concept was carried out with the IRSN program MELODIE. GRS contributed its expertise with the GRS probabilistic tool SUSA for the analysis of uncertainties of the modellings.

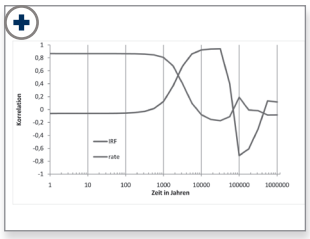


MODEL DRAWING

Fig. 70
Schematic representation of an emplacement drift with release (arrows) of the iodine 129 from the casks into the surrounding host rock

MELODIE. The simplified modelling of the release of the radionuclide Iodine-129 with the programme MELODIE considers as input parameter the inventory, a so-called »instant release fraction« (IRF), as well as a long-term dissolution rate of the fuel element and the associated uncertainties.

SUSA. The program package SUSA analyses the impact and interaction of parameter uncertainties on the uncertainty of the modelling results. With the additional sensitivity analysis the uncertainties of the parameters can be ranked according to their influence on the uncertainty of the modelling result.



MODELLING RESULT

Fig. 71
Correlation of the release of Iodine-129 from the host rock with the instantaneously released fraction (IRF) and the dissolution rate, respectively

Methodology. The distribution functions of the estimated uncertainties were assigned to these parameters. The probabilistic input values for the parameters were determined with the GRS program package SUSA. The modelling results for the released activity of Iodine-129 in Becquerel (Bq) obtained with the programme MELODIE using these values were evaluated. This allows to identify the link between the uncertainty of the modelling results and the uncertainty of the input parameters (see Fig. 71 »MODELLING RESULT«).

Results

The results of the analyses show that the activity release of Iodine-129 into the host rock within the first thousand years is correlated highly (close to 1) with the instant release fraction (IRF). The dissolution rate (rate) is irrelevant in this period. The dissolution rate of the fuel element is decisive for the activity release from approx. 2,000 years. Both influences are becoming meaningless for the modelling result form approx. 30,000 years.

Assessment of the results and outlook. The probabilistic sensitivity analysis with SUSA was applied as an example to a modelling of radionuclide release and transport with MELODIE with three parameters. The actual complexity of the analysis is highly dependent on the model properties and on the number of uncertain parameters included in the analysis. From GRS's point of view, it could be successfully demonstrated within the scope of MICADO that the used model calculations are accessible for a probabilistic analysis.

An in-depth use of the sensitivity analysis taking more parameters into account could demonstrate unexpected dependencies on the one hand, and the relevance of parameters for modelling results on the other hand. From the regulatory perspective the uncertainties and interrelationships related to the release of radionuclides within a safety case can be identified. ∎

MODELLING RESULT

Fig. 71
Correlation of the release of Iodine-129 from the host rock with the instantaneously released fraction (IRF) and the dissolution rate, respectively

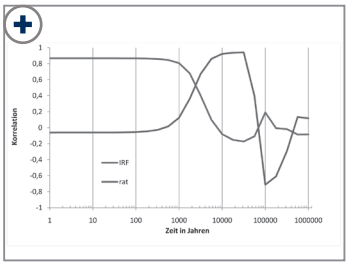


Fig. 71 Master file